### Glen Canyon Dam Adaptive Management Work Group

Ad Hoc Committee on Strategic Planning

### Report to AMWG, June 2000 January 2001

### Strategic Plan Update

This document consists of the following components, which should be viewed as an integrated whole. Together, they guide the work of the Glen Canyon Dam Adaptive Management Work Group.

- Vision and Mission
- Principles
- Goals
- Objectives
- Glossary

### Vision and Mission

The Grand Canyon is a homeland for some, sacred to many, and a national treasure for all. In honor of past generations, and on behalf of those of the present and future, we envision an ecosystem where the resources and natural processes are in harmony under a stewardship worthy of the Grand Canyon.

We advise the Secretary of the Interior on how best to protect, mitigate adverse impacts to, and improve the integrity of the Colorado River ecosystem affected by Glen Canyon Dam, including natural biological diversity (emphasizing native biodiversity), traditional cultural properties, spiritual values, and cultural, physical, and recreational resources through the operation of Glen Canyon Dam and other means.

We do so in keeping with the federal trust responsibilities to Indian tribes, in compliance with applicable federal, state, and tribal laws, including the water delivery obligations of the Law of the River, and with due consideration to the economic value of power resources.

This will be accomplished through our long-term partnership utilizing the best available scientific and other information through an adaptive ecosystem management process.

### **Principles**

The Glen Canyon Dam Adaptive Management Work Group embraces the following Principles. They guided development of the Goals and Objectives for the Glen Canyon Dam Adaptive Management Program (GCDAMP). These Principles are:

- The Goals represent a set of desired outcomes that together will accomplish our Vision and achieve the purpose of the Grand Canyon Protection Act. Some of the Objectives and actions that fall under these Goals may not be the responsibility of the GCDAMP, and may be funded by other sources, but are included here for completeness.
- 2. The construction of Glen Canyon Dam and the introduction of non-native species have irreversibly changed the Colorado River ecosystem.
- 3. Much remains unknown about the Colorado River ecosystem below Glen Canyon Dam and how to achieve GCDAMP ecosystem Goals.
- 4. The Colorado River ecosystem is a managed ecosystem. An ecosystem management approach, in lieu of an issues, species, or resources approach, will guide our efforts. Management efforts will prevent any further human-induced extirpation or extinction of native species.
- 5. An adaptive management approach will be used to achieve GCDAMP ecosystem Goals, through experimentation and monitoring, to meet the intent of the Grand Canyon Protection Act, the Environmental Impact Statement, and the Record of Decision.
- 6. Management actions, including changes in dam operations, will be tried that attempt to return ecosystem patterns and processes to their range of natural variability. When this is not appropriate, or beyond the range of operational flexibility of the dam, experiments will be conducted to test other approaches.
- 7. Because management actions to achieve a Goal may benefit one resource or value and adversely affect another, those action alternatives that benefit all resources and values will be pursued first. When this is not possible, actions that have a neutral impact, or as a last resort, actions that minimize negative impacts on other resources will be pursued, consistent with the final Glen Canyon Dam EIS and the Record of Decision.
- 8. Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.

### Protect or improve the aquatic foodbase so that it will sup iable populations of desired species at higher trophic level.

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	D#	
some action	Perform	
element	On some	
attribute	On some	
	At some place	
	From the current level	
,	To the target level	
	el Comments	

	attain macrophytes Composition Glen Cany	3 Maintain or Aquatic Biomass Mainstem		River	Composition Dam to Pa	2 Maintain or Benthic Biomass Mainstem Glen Cany		Composition	River, Linkages: See  1 Maintain or Algae and Biomass Mainstem	The target for all the Management Objectives in Goal 1 is adequate food availability to support trout and native fish at
	macrophytes						<del> </del>	periphyton	or Algae and	all the Management Ob
Production	Composition	Biomass	Production		Composition	Biomass	Production	Composition	River Lir Biomass	ectives in Goal 1 is
Dam to Paria	Glen Canyon	Mainstem from		River	Dam to Paria	Mainstem from Glen Canyon		Glen Canyon Dam to Paria River	Mainstem from	adequate food avail
Information Need	Information Need	Information Need	Information Need	3.6% Gammarus 5.5% Oligochaetes 0.1% Simulium 28.8% Midges 3.8% Miscellaneous 57.7% Gastropoda (Cobble) <sup>(27)</sup> 1.0% Worms 0.9% Gammarus 35.7% Oligochaete 22.3% Midges (Pool) <sup>(27)</sup>	0.4% Worms	5.0 g/m² (Cobble) <sup>(27)</sup> 1.0 g/m² (Pool) <sup>(27)</sup>	Information Need	2.7 g/m² (Pool)(27) 49.60% Cladophora 33.10% Chlorophyta 9.10% Fontinalis 3.35% Chromophyta 2.40% Rhodophyta 2.50% Cyanobacteria (27)	River. Linkages: See the numbers of fish desired under Goals 2, 3, a see Mainstem from 17.5 p/m² (Cobble)(27) 150 s	lability to support trout and nati
Information Nand	Information Need	Information Need	Information Need		Information Need	5000 g/m <sup>2(27)</sup>	Information Need	Obtain from literature	ls 2, 3, and 4.	ve fish above the Paria River, ar
2,			Metric is g/m²/time	species.	Metric is relative % of	Also see McKinney et al. 1999 <sup>(22)</sup>	Metric is g/m²/time of Cladophora	Metric is % of algal species that support upright diatoms	Also see McKinney et al	bove the Paria River, and native fish below the Paria

Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

															4	ID#
													Maintain or attain		Maintain or attain	Perform
													Algae and periphyton		element Algae and periphyton	On some
													Distribution	Production	Biomass  Composition	On some
	,					12	•						Mainstem below the Paria River		Mainstem below the Paria River	At some place
205	127	68	61	2	Pool(2/)	205	127	68	61	2	Cobble <sup>(27)</sup>	Mile	· · · · ·	Inforn	12.21 g/m² ( 0.35 g/m² ( 29.9% Clada 23.7% MAN 46.6% Oscil (Cobble) <sup>(27)</sup> 51.0% Clada 48.9% MAN 0.1% Oscil (Pool) <sup>(27)</sup>	
71.2	15.2	80.0	28.6	60.0	ء ا	63.7	5.6	8.7	22.4	49.3	<sub>e</sub> (27)	% Cladopho	ra	Information Need	12.21 g/m² (Cobble)(2) 0.35 g/m² (Pool)(27) 29.9% Cladophora 23.7% MAMB 46.6% Oscillatoria (Cobble)(27) 51.0% Cladophora 48.9% MAMB 0.1% Oscillatoria (Pool)(27)	rom the
28.5	84.8	20.0	71.4	40.0		12.4	12.4	7.2	43.1	43.3		% MAMB		æd	hora hora hora hora	From the current level
0.3	0.0	0.0	0.0	0.0		23.9	82.0	84.1	34.5	7.4		% Oscillator	ia 			evel
									•				Information Need	Information Need	50 g/m <sup>3(27)</sup> Obtain from literature	To the target level
														Metric is g/m²/time	Metric is relative % of algal species. MAMB is for miscellaneous algae, macrophytes, and bryophytes	Comments

### $Go_{L}$ Protect or improve the aquatic foodbase so that it will supp table populations of desired species at higher trophic level.

0.2018.00		ID#	
	some action	Perform	
	element	On some	
***************************************	attribute	On some	
THE PARTY OF THE P		At some place	
		From the current level	
		To the target level	
		Comments	

			6																									•		S
		attain	Maintain or																	•	•									Maintain or attain
		macrophytes	Aquatic																											Benthic invertebrates
Distribution	Production	Composition	Biomass								Distribution	Production																	Composition	Biomass
		the Paria River	Mainstem below																											Mainstem below the Paria River
Obtain from literature	Obtain from literature	Obtain from literature	Obtain from literature	(Cobble at Mile 2)(27)	1580 Gastropod	20 Miscellaneous	2150 Midges	10 Simulium	120 Oligochaetes	500 Gammarus	20 Worms	Information Need	(Pool) <sup>(27)</sup>	4.0% Gastropod	1.2% Miscellaneous	48.9% Chironomid	14.3% Simulium	30.1% Oligochaete	1.1% Gammarus	0.4% Worm		(Cobble) <sup>(27)</sup>	21.0% Gastropod	3.6% Miscellaneous	55.4% Chironomid	4.3% Simulium	8.2% Oligochaete	7.1% Gammarus	0.4% Worm	0.960 g/m <sup>2</sup> (Cobble) <sup>(27)</sup> 0.054 g/m <sup>2</sup> (Pool) <sup>(27)</sup>
Information Need	Information Need	Information Need	Information Need			***					Information Need	Information Need																	Obtain from literature	Obtain from literature
					,							Metric is g/m²/time																species.	Metric is relative % of	

## Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

To the target level

₽	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
7	Maintain or	Foodbase drift	Abundance	Mainstem below	0.024 g/m³/s (Plants)	Obtain from literature	
	attain			GCD	0.056 g/m³/s (Detritus) 0.001 g/m³/s (Inverts)		
			Composition		29.2% (Plants)	Obtain from literature	CPOM is coarse particulate
			,		69.3% (Detritus)		organic matter. FPOM is
					1.1% (CPOM inverts)		fine particulate OM.
					0.4% (FPOM inverts)		

### Gou laintain or attain viable populations of existing native fis. . . remove jeopardy from humpback chub and razorback suc

	)	10		9		∞		ID#
	Attain	Establish		Maintain or attain		Maintain or attain	some action	Perform
	Humpback chub	Humpback chub		Humpback chub (51 mm to 150 mm)	•	Humpback chub (150 mm and larger)	element	On some
Health	Condition	Populations		Abundance		Abundance	attribute	On some
LCR and mainstem within 3 miles of LCR Mainstem except within 3 miles of the LCR	LCR and mainstem within 3 miles of LCR Mainstem except within 3 miles of the LCR	CRE downstream of GCD	Mainstem except within 3 miles of the LCR	LCR and mainstem within 3 miles of LCR	Mainstem except within 3 miles of the LCR	LCR and mainstem within 3 miles of LCR		At some place
Information Need Information Need	Information Need Information Need	One self-sustaining population in the LCR	0-74 captures/trip <sup>(9)</sup>	Obtain from literature	225 individuals <sup>(3: 36)</sup>	8096 individuals <sup>(3; 36)</sup>		From the current level
Information Need Information Need	Information Need Information Need	One additional self- sustaining population	Information Need	Information Need	Information Need	Information Need		To the target level
of jeopardy.	The target is viable	The target is viable populations and removal of jeopardy.	Metric is "catch per unit effort" (CPUE). See Gorman and Bramblett. (9) See synthesis by Coggins.	The target is viable populations and removal of jeopardy.	Target to be based on 91- 96 population estimate, PVA, & N <sub>e</sub> .	The target is viable populations and removal of jeopardy.		Comments

Goal 2. Maintain or attain viable populations of existing native fish and remove jeopardy from humpback chub and razorback sucker.

	15	14	12	ID#
	Maintain	Attain	Maintain or attain  Reduce	Perform some action
Speckled dace	Flannelmouth sucker	Razorback sucker	Humpback chub  Non-native fish	On some element
	Abundance	Populations	Spawning  Predation on native fish  Competition with native fish	On some attribute
	CRE below GCD	CRE below GCD	LCR and mainstem within 3 miles of LCR Mainstem except within 3 miles of the LCR CRE below GCD	At some place
391 captures (18.2%) <sup>(9)</sup>	113 captures (5.3%) <sup>(9)</sup>	0 individuals <sup>(9)</sup>	Information Need Information Need Information Need Information Need	From the current level
Information Need	Information Need	Information Need	Information Need Information Need Information Need Information Need	To the target level
The target is viable populations and removal of jeopardy.	Appropriate metric to be determined.	Target is capability of the habitat to support the species.	See Gorman and Bramblett. (9)  The target is viable populations and removal of jeopardy.  Metric for 'predation on native fish' is rate of predation. See Gorman and Bramblett. (9)  The target is reduction of non-native fish predation and competition so they do not impinge on native fish viability. Suggested metrics for this MO are stomach content analysis, abundance, and distribution. Linkages: The native fish MOs in Goal 2 and Goal 3.	Comments

ID#	Perform	On some	On some	At some place	From the current level	To the target level	Comments
	some action	element	attribute				
16	Restore	Colorado	Abundance	CRE	0 individuals <sup>(9)</sup>	Information Need	
		pikeminnow		downstream of			
		Bonytail		GCD	0 individuals <sup>(9)</sup>	Information Need	
		Roundtail Chub			0 individuals <sup>(9)</sup>	Information Need	
		River otter			0 individuals <sup>(10)</sup>	Information Need	

# Goal 4. Maintain a wild reproducing population of rainbow trout above <del>Lees Ferrythe Paria River</del>, to the extent practicable and consistent with the maintenance of viable populations of native fish.

### NOTE ON GOAL 4: The purpose of this goal is recreation. It is limited by MO 13.

	D#	
some action	Perform	
element	)n s	
attribute	On some	
element attribute	At some place	
	From the current level	
	Comments	

					17	This &
				attain	Maintain or	oal is self-expla
					Rainbow trout	natory and does no
Spawning	Health	Condition	Growth rate		Abundance	t need a separate qu
		River	Dam to Paria	☐ Glen Canyon	Mainstem from	nalitative target. Link
Information Need	Information Need	$W_r = 0.82^{(23)}$	15" by Age III <sup>(23)</sup>	individuals <sup>(23)</sup>	262,000 Age II+	This goal is self-explanatory and does not need a separate qualitative target. Linkages: See Issue Paper B (trout).
Information Need	Information Need	$W_t = 0.90$	18" by Age III		100,000 Age II+ individuals	<u>u).</u>
	Metric is level of disease and parasite infections					

### Goal 5. Establish water temperature, quality, and j. ynamics to achieve GCDAMP ecosystem goals.

NOTE FOR GOAL 5: The phrase, "to achieve GCDAMP ecosystem goals," indicates that this goal is a method to achieve certain other goals. In this case, "ecosystem goals" includes biological goals, recreational goals, and the cultural goal.

	•			flame			
	criteria <del>Use decision process</del>	•		maintenance			
	Current ROD operating	ROD operating criteria		Habitat			
	criteriaUse decision process	to April)					
	Current ROD operating	Maximum 45,000 cfs (March		BHBF flows			
experimental flows.	criteria			operations			
See MO 50 for	Current ROD operating	ROD operating criteria	Mainstem	Power plant	Flow dynamics	Maintain	20
		12.	recreational experience, and cultural resources. Linkages: Goals 1-3, 8-10, and 12	ources. Linkages: G	e, and cultural reso	tional experienc	гестеа
s pur	tern willow flycatcher, riparian i	optimizes conditions for the featured resources. The targeted resources are foodbase, native fish, trout, Southwestern willow flycatcher, riparian and spring communities, the	resources are foodb	ources. The targeted	for the featured reso	zes conditions	optim
exibi	of the dam, the range of legal fl	The target for MO 19 is water quality based on the range of natural variability, the range of operational flexibility of the dam, the range of legal flexibility, and the range that	natural variability, th	sed on the range of r	is water quality bas	rget for MO 19	The ta
phosphorus, microbes, and others. Data available from NASQWAN <sup>(35)</sup>							
DO, nitrogen,		parameters to use).					
nutrients, salinity, pH,	use decision process	specific water quality	1110111000	Zamity	T alci	INTGILIEGILI	ţ
Parameters may include	Ohtain from literature and	Information Need (for the		10 Maintain Water Oneality	Water	Maintain	10
ıcludi	rces, including native fish, and including foodbase and trout Vision-Mission statement	Temperature patterns should have as their first priority the improvement of conditions for native biological resources, including native fish interactions. This is based on the executed status of native fish. I inkages: MO 13: Principles 4, 6, and 7, and the Vision-Mission statement.		r first priority the in	should have as thei	erature patterns	Temp
	i e roodrase, mirre nsu, uou, m	iange of legal frexibility, and the failge that optimizes conditions for the readilies resources. Targeton resources are noctoose, matter that, from, and propie the international safety – microorganisms and hypothermia).	Oils to: the reatment	a).	range or regar recommy, and the range man safety – microorganisms and hypothermia)	- microorganis	safety
lexib	ability, the range of operational flexibility of the dam, the	The target for MO 18 is a temperature range and pattern of seasonal variability based on the range of natural variability	asonal variability ba	nge and pattern of se	is a temperature rai	rget for MO 18	The ta
	Ose decision process	Intol mation (Need		variability of temperature			
mainstem.				range			
Target may include	Use decision process	6.93-18.56°C <sup>(17)</sup>	Mainstem	Temperature	Water	Attain	18
				attribute	element	some action	
-	To the target level	From the current level	At some place	On some	On some	Perform	ID#

### Goal 6. Increase fine sediment storage Maintain or attain levels of sediment within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

includes biological goals, recreational goals, and the cultural goal NOTE FOR GOAL 6: The phrase, "to achieve GCDAMP ecosystem goals," indicates that this goal is a method to achieve certain other goals. In this case, "ecosystem goals."

			attribute	element	some action	
o the target level Comment	From the current level	At some place	On some	On some	Perform	ID#

23 22 biological, and cultural goals: 1-4, 7-10, and 12. habitat and preserving sites through filling in arroyos. For recreational goals, the purposes are camping beaches and trout spawning habitat. Linkages: Recreational, system to achieve ecosystem patterns in these goals). For the biological goals, the purposes are habitat and nutrient storage. For the cultural goal, the purposes are plant The target for Goal 6 is enough sediment to achieve the biological, recreational, and cultural goals. Given limited sediment inputs, we need to retain enough sediment in the Maintain or attaın attaın Maintain or Maintain or Sediment Sediment Sediment Distribution Distribution Abundance Grain-size Abundance Abundance Distribution Grain-size Grain-size Eddies up to below up to Main channe plant capacity between power power plant power plant and maximum Shorelines capacity capacity 0.80m (Grand Canyon) (12) 0.15-0.18mm (31) 0.15-0.18 mm<sup>(12; 31)</sup> 0.3-0.4 mm<sup>(12; 31)</sup> 0.60m (Marble Canyon) 0.37m (Glen Canyon) 289,120 m<sup>3</sup> (35 sites)<sup>(12;31)</sup> 329,000 m<sup>3</sup> (35 sites)<sup>(12;31)</sup> Information Need Information Need Information Need Information Need
Information Need Information Need Information Need Information Need Information Need Information Need Information Need Information Need consider spawning habitat Target level should average. Target level Metric is # sandbars by volume (m<sup>3</sup>) as a rolling Metric is area (m<sup>\*</sup>) and Metric is # sandbars by average volume (m') as a rolling Metric is area (m") and consider spawning habitat reach. Target level should Metric is # sandbars by should consider spawning volume (m') as a rolling Metric is area (m') and average for trout in Glen Canyon for trout in Glen Canyon. Also see Kondolf. (16) Canyon. habitat for trout in Glen reach

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### Revised Strategic Plan 2000-12-04 redlined

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		-
25	24	ID#
Maintain	Attain and maintain	Perform some action
Kanab ambersnail	Kanab ambersnail	On some element
Habitat	Population	On some attribute
Vasey's Paradise	Vasey's Paradise AZ (except Vasey's Paradise)	At some place
82-99m <sup>2</sup> (monkeyflower) 36.6 m <sup>2</sup> (watercress) (area below 70,000 cfs stage) <sup>(24)</sup>	7100 (April 1999) 6400 (May 1999) 20,000 (July 1999) 35,000 (Sept/Oct 1999) (Individuals below 70,000 cfs stage) <sup>(24)</sup> 3 individuals (Keyhole) 21 individuals (Elves) 0 individuals (Deer Creek) <sup>(1)</sup>	From the current level
Information Need	Information Need Information Need	To the target level
Target is level needed to sustain a viable population. "Viable" includes the entire population, not just those below 70,000 cfs.	The metric is the population parameter(s) that indicate viability. Target is a viable population. "Viable" includes the entire population, not just those below 70,000 cfs.  The metric is the population parameter(s) that indicate viability. Target is a viable population. "Viable" includes the entire population, not just those below 70,000 cfs.	Comments

# Goal 8. Protect the presence of southwestern willow flycatcher and its critical habitat in a manner consistent with riparian ecosystem goals.

NOTE ON GOAL 8: The phrase, "in a manner consistent with riparian ecosystem goals," is intended to indicate a hierarchy or order of precedence. That is, the accomplishment of this goal should be undertaken in such a way that the likelihood of achieving Goal 9 is not impaired.

ID#	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
26	Maintain or increase	Southwest willow	Abundance	CRE below GCD	12 breeding pairs <sup>(26)</sup>	Information Need	Target is the capability of the habitat to support the
		flycatcher					speciesnumber of breeding pairs that the habitat is capable of supporting.
			Distribution	CRE below GCD	Information Need	Information Need	Target is the capability of the habitat to support the species distribution of
							breeding pairs that the habitat is capable of supporting.
			Fledging success	CRE below GCD	Information Need	Information Need	See GCMRC (7) The target is the level needed
							to maintain the target level in the Abundance attribute of MO 26.
27	Maintain	Southwest willow	Critical Hhabitat	CRE below GCD	Information Need	Information Need	The target is the capability of the habitat to
28	Reduce	Brown-headed	Brood	CRE	50% of nests parasitized(2)	Information Need	The target is the level
	1	cowbird	parasitism		,		needed to maintain the
							Southwestern willow
							flycatcher in MO 26.

### Goal 9. Protect or improve the bio. arian and spring communities.

NOTE ON GOAL 9: This goal is intended to help achieve the biological, cultural, and recreational goals.

ID#	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
29	Maintain	Marsh	Abundance	CRE below GCD	1215 patches (4.6 ha) <sup>(7)</sup>	Information Need	See Kearsley <sup>(15)</sup> and Stevens et al. <sup>(29)</sup> The
			Composition		Information Need	Information Need	target is an achievable and appropriate mix of these
			Distribution		Information Need	Information Need	types of communities.
30	Maintain	New high water zone	Abundance	CRE below GCD	Information Need	Information Need	All four communities are important for maintaining
			Composition		Information Need	Information Need	the diversity of wildlife. The Old High Water Zone
			Distribution		Information Need	Information Need	of the threat of losing it.
31	Maintain	Old high water zone	Abundance	CRE below GCD	Information Need	Information Need	is through high flows.
			Composition		Information Need	Information Need	negative effect on
			Distribution		Information Need	Information Need	Water Zones.
32	Maintain	Sand beach	Abundance	CRE below GCD	Information Need	Information Need	Considering the legal and
			Composition		Information Need	Information Need	the NPS to protect natural landscapes and native
			Distribution		Information Need	Information Need	species and communities, considering regenerative
							capabilities, and recognizing the dynamic
							and successional nature of
							other three zones would
							be a lower priority.

Goal 9. Protect or improve the biotic riparian and spring communities.

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		Reduce		Maintain		some action	Perform
		Invasive non- native species	important species	Culturally		element	On some
	Distribution	Abundance	Distribution	Abundance		attribute	On some
		CRE below GCD	GCD	CRE below		At some place	At some place
	Information Need	95+ species (Plants) <sup>(28)</sup> 3 species (Birds) <sup>(28)</sup>	Information Need	157 species (Plants) <sup>(21; 30)</sup>		LIOHI GIC CMI CH ICACI	From the current level
	Information Need	Information Need	Information Need	Information Need		TO THE PARENT LEVEL	To the target level
Abundance refers to number of individuals within the species. These species should be limited to invasive ones, not just non-natives.	not impinge on biological, recreational, and cultural resources.	The target is the level at which these species do				Commicines	Comments

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ID#	35						:	36							37										·
Perform some action	Maintain							improve	•						Maintain or	nicicase									
On some element	Visitor							Spectrum	•						Camping	DEACHES									
On some attribute	Physical access	and safety						Quality and			•				Size	Quality	\(\frac{1}{2}\)	Number		Distribution			<del></del>		
At some place	Mainstem							Glen Canyon							Mainstem										
From the current level	Information Need							Information Need							Information Need	Information Need	ALIA CA ALIMONOMIA A TOPOGO	262 campsites <sup>(14)</sup>		37% of campsites in critical reaches(14)					•
To the target level	Information Need							GLCA Management Plan							Information Need	Information Need		Information Need		Information Need					
Comments	Target level should be	within the capacity of the CRE to absorb	visitor impacts. Target	level should consider	GLCA and GRCA	Management Plans. See	Myers et al.	NPS studies underway.	within the capacity of	the CRE to absorb	level should consider	GLCA and GRCA	Management Plans. See	Myers et al. (23)	Target level should be	CRF to absorb visitor	impacts. Target level	should consider GLCA	and GKCA Management	Plans. See Myers et al. (27) Metric for Quality	includes parameters for	vegetation, sanitation, and	shade Metric for	Distribution is number of	identified reach

### Goal 10. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

NOTE ON GOAL 10: The phrase, "within the framework of GCDAMP ecosystem goals," is intended to indicate a hierarchy or order of precedence. That is, the accomplishment of this goal should be undertaken in such a way that the likelihood of achieving the biological goals and the cultural goal is not impaired.

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38			ID#
Maintain or improve		some action	Perform
Rapids		element	On some
Navigability		attribute	On some
Mainstem			At some place
Information Need			From the current level
			To the target level
Target level to be developed from NPS on-river accident rates. See Myers et al. (25) The target			To the target level Comments

39	38
Maintain or enhance	Maintain or improve
Experience	Rapids
Wilderness	Navigability
Grand Canyon	Mainstem
Information Need	Information Need
Information Need	Information Need and Decision Process
Metric to include parameters for primitive character, unconfined experience, undeveloped natural and wild character, opportunities for solitude, sounds of nature and scenic beauty.  The NPS is probably responsible for monitoring this MO.	Target level to be developed from NPS on-river accident rates. See Myers et al. (25) The target should address navigability across the range of flows allowed within the ROD. The metric is the number of accidents per rapid at each flow.

### Goal 11. Maintain or increase power and energy gener.

within the framework of GCDAMP ecosystem goals.

NOTE ON GOAL 11: The phrase, "within the framework of GCDAMP ecosystem goals," is intended to indicate a hierarchy or order of precedence. That is, the accomplishment of this goal should be undertaken in such a way that the likelihood of achieving the biological goals, the recreational goals, and the cultural goal is not impaired.

	40		ID#
		_	#
increase	Maintain or	some action	Perform
flexibility	Power	element	On some
flexibility	Generation	attribute	On som
	GCD		At some place
practices <sup>(33)</sup>	ROD and current operating		e At some place From the current level
	Information Need		To the target level Comments
			Comments

# Goal 12. Preserve, protect, manage, and treat Ecultural resources within the river corridor shall be preserved, protected, managed and treated for the inspiration and benefit of past, present and future generations.

ID#	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
4	Preserve	Register-eligible properties	National Register	APE	Information Need	100% of extant historic	Target level should
			integrity			•	impacts. See USBR <sup>(32)</sup> and Leap et al. (19)
42	Preserve	Other cultural	Cultural values	CRE	Information Need	Information Need	Target level should
		i esources					impacts.
43	Attain and	Management	Consultation	CRE	Information Need	100% of management actions	See USBR <sup>(32)</sup>
44	Protect and	Traditional	Dhysical access	CBE	Information Name	I-6	G TICTN (34)
	maintain	cultural		•			Deer Contra
		resources					
45	Integrate	Information	Cultural and	CRE	Synthesis report <sup>(30)</sup>	Information Need	
			other resources				

							_
# level Comments	To the target	From the current level	At some place	On some	On some	Perform	D#

		48	47						46
		Attain and maintain	Attain and maintain					attain	Maintain or
	Staketholders	AMP composed of all	Monitoring and research program					Cata	Socio-economic
Participation	uses experimentation, monitoring & research	That acknowledges	Natural, cultural, and recreational resources	Tribal & spiritual values	Non-use values	Recreation	Wilderness	Air quality	Hydropower
N/A		N/A	CRE	N/A	N/A	N/A	N/A	N/A	N/A
See meeting records.		Information Need	GCMRC Strategic Plan	Information Need	Information Need	Information Need	Information Need	Information Need	Information Need
Information Need		Information Need	Updated GCMRC Strategic Plan	Information Need	Information Need	Information Need	Information Need	Information Need	Information Need
The target is representation of all stakeholders at every AMWG and TWG meeting and other subcommittee meetings to which the stakeholders have committed, and review by all stakeholders of relevant program documents.			Current and target levels should include a planning document and an outside peer review document.		designation of the state of the	is needed for adequate	much socioeconomic data	we have on the attributes.	The current level is how

## Goal 13. Maintain a high-quality monitoring, research, and adaptive management program.

51	50	49	ID#
Conduct	Conduct	Attain and maintain	Perform some action
Management experiments	Experimental flows	Full tribal participation Funding	On some element
Other management actions	Flow dynamics	Funding Tribal participation	On some attribute
CRE	Mainstem	АМР	At some place
Information Need	Information Need	\$75,000 (Appropriated) \$400,000 (Power revenues)	From the current level
Information Need	Information Need	\$475,000 (Appropriated in FY2002)Information need	To the target level
Target level is the experiments needed to gain critical understanding of ecosystem function under different management alternatives outside of dam operations.	See GCMRC, (6) Webb et al. (37) and Topping et al. (31) Target level is the experiments needed to gain critical understanding of ecosystem function under different dam operations.	The target is a level of funding adequate to meet each tribe's needs to participate in the Adaptive Management Program. Linkage: Vision/Mission statement, particularly the mention of federal trust responsibilities.	Comments

Goal 13. Maintain a high-quality monitoring arch, and adaptive management program.

	54				53									********	52	ID#
	Maintain or attain				Maintain or attain										Build	Perform some action
	Participation				Funding										AMP	On some element
	Externally- funded investigators	Power revenues	State Agency	Appropriated	Foundation and Corporate										Public support	On some attribute
	CRE	N/A	N/A	N/A	N/A										N/A	At some place
	Information Need	\$6.22M (for GCMRC) \$1.443M (for BOR)	Obtain from literature	\$75,000 (FY 2000)	<b>\$</b> 0				· · · · · · · · · · · · · · · · · · ·			,	~		Information Need	From the current level
	Information Need	Information Need	Information Need	\$1,485,000 (FY 2002)	Information Need						<del></del>	-			Information Need	To the target level
NPS, AGFD, etc.  The target is contributions to meeting Information Needs by externally funded investigators.  NOTE: Incentives could include donated office space, partial funding, letters of support, facilitated access, and logistical support,	Current and target levels should include small and cost-shared projects in			,	The target is adequate funding to meet the goal	base.	and a diverse funding	for AMP experiments and	activities. The target is	AMWG member	publications; various	Outreach Committee:	and tours: AMWG	GCMRC and BOK web	Metric should include	Comments

## Goal 14: Build a broad, effective outreach program. Goal 15: Broaden the funding base to achieve GCDAMP Goals and Objectives.

NOTE ON GOALS 14 AND 15: These goals are now part of Goal 13.

### Glossary

### ADAPTIVE MANAGEMENT

Adaptive management is an iterative process, designed to experimentally compare selected management actions by evaluating alternative hypotheses about the ecosystem being managed. It consists of three parts: management actions, monitoring, and adaptation. Management actions are treated as experiments subject to modification. Monitoring is conducted to detect the effects of the management actions. Finally, management actions are refined based on the enhanced understanding about how the ecosystem responds.

### **BIODIVERSITY**

Biodiversity is "the variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels [including] ... the variety of ecosystems..." (38)

### **BIOLOGICAL GOALS**

Biological goals include Goal 1 (foodbase), Goal 2 (native fish), Goal 3 (extirpated species), Goal 7 (Kanab ambersnail), Goal 8 (Southwestern willow flycatcher), and Goal 9 (riparian and spring communities).

### BIOTIC COMMUNITY

A biotic community is a "group of organisms ... that co-occur in the same habitat or area and interact through trophic and spatial relationships..." (20)

### COLORADO RIVER ECOSYSTEM

The Colorado River ecosystem is the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park. It includes the downstream inundation level to which dam operations impact physical, biological, recreational, cultural, and other resources. The scope of GCDAMP activities may include limited investigations into some tributaries (e.g., the Little Colorado and Paria Rivers).

### CONCEPTUAL MODEL

A conceptual model is an "assessment of the dynamics of the more important compartments and fluxes of material or energy in a system [i.e., patterns and processes], or of changes in a population." (20) A conceptual model is a heuristic tool to provide a framework for thinking about how an ecosystem functions and to discover gaps in our knowledge.

### **CULTURAL GOAL**

Cultural goal refers to Goal 12.

### **CULTURAL RESOURCES**

Cultural resources includes, but is not necessarily limited to, any prehistoric or historic district, site, building, structure, landscape, or object included in, or eligible for inclusion in the National Register, including artifacts, records, and material remains related to such a property or resource. Properties of traditional religious and cultural importance to an Indian tribe are included in this definition under Section 101(d)(6)(A) of NHPA.

### ECOSYSTEM

An ecosystem is "a community of organisms and their physical environment interacting as an ecological unit." (20)

An ecosystem consists of patterns and processes that are dynamic and occur within a particular range of temporal and spatial variability.

### **ECOSYSTEM INTEGRITY**

Ecosystem integrity is "the ability to support and maintain a balanced, integrated, adaptive biological system having the full range of elements (genes, species, and assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region." (13) Ecosystem integrity is related to ecosystem resilience (i.e., the capacity to maintain characteristic patterns and processes) following a disturbance.

### Glossary

### **ECOSYSTEM MANAGEMENT**

An ecosystem management approach differs from an issue-, species-, or resource-specific approach. Ecosystem management is a method for sustaining or restoring ecosystems and their functions and values. "It is goal driven, and it is based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries." (11) Ecosystem management is a process that attempts to mimic appropriate ecosystem patterns (abundance and distribution of species and habitats) and ecosystem processes (drivers of ecosystem patterns). It includes managing for viable populations of all native species.

### **ECOSYSTEM PATTERNS**

Ecosystem pattern is the abundance of species, biotic communities, and physical habitats, as well as their spatial and temporal distribution. This is a broader concept than "composition and structure." Composition usually refers only to species presence or absence, and structure usually refers to the distribution of biotic communities.

### **ECOSYSTEM PROCESSES**

Ecosystem processes are the abiotic (i.e., non-living) and biotic (i.e., living) functions, disturbances, or events that shape ecosystem patterns. There are physical processes (e.g., fire, hydrologic, geomorphic, and climatic regimes; air chemistry, nutrient cycling), biological processes (e.g., competition, predation, herbivory, parasitism, disease, migration, dispersal, gene flow, succession, recruitment, maturation), and anthropogenic processes (e.g., habitat conversion, novel toxins, vandalism).

### **MONITORING**

Monitoring is the "collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective." (4) Monitoring needs to produce data of sufficient statistical power to detect a trend if in fact it is occurring. (8) Monitoring differs from inventorying, which is the measurement of environmental attributes at a given point in time to determine what is there. It also differs from research, which is the measurement of environmental attributes to test a specific hypothesis.

### **QUALITATIVE TARGET**

An articulation of the purpose of one or more Management Objectives, in order to give a description in words of what the humerical target levels are intended to accomplish, and to give direction and guidance to the persons who developed the quantitative targets.

### RANGE OF NATURAL VARIABILITY

The Range of Natural Variability is the spatial and temporal variation in ecosystem patterns and ecosystem processes under which the ecosystem has evolved. The range of natural variability for ecological processes is usually defined by their frequency (e.g., number/year), intensity (e.g., cubic feet per second), duration (e.g., number of days), magnitude (e.g., acres), seasonally, and rate of change. See Landres<sup>(18)</sup> for a full discussion.

### REASONABLE AND PRUDENT ALTERNATIVE

"Reasonable and prudent alternatives refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat." (5)

### REASONABLE AND PRUDENT MEASURE

"Reasonable and prudent measures refer to those actions the Director believes necessary or appropriate to minimize the impacts, i.e., amount or extent of incidental take." (5)

### RECOVERY

Recovery is improvement in the status of a listed species to the point at which listing is no longer appropriate, under the criteria set out in section 4(a)(1) of the Endangered Species Act (5).

### RECREATIONAL GOALS

Recreational goals include Goal 4 (trout) and Goal 10 (recreation).

### Glossary

### REMOVAL OF JEOPARDY

To "jeopardize the continued existence of [a listed species] means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." (5) Removing (or avoiding) jeopardy is intended to be accomplished through the implementation of reasonable and prudent alternatives.

### RIPARIAN ECOSYSTEM

The riparian ecosystem is the streamside zone that is influenced by riverine processes, e.g., flood regime and distance to subsurface water.

### RIVERINE ECOSYSTEM

The riverine ecosystem is any area typically inundated by the river.

### VIABLE POPULATION

A population is considered viable when there is a high chance of persistence over a long timeframe without demographic or genetic augmentation. Population viability is not the same as "recovery" or "removal of jeopardy" for a species. However, the concept of population viability is an important consideration in determining recovery and removal of jeopardy.

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### Vision and Mission

The Grand Canyon is a homeland for some, sacred to many, and a national treasure for all. In honor of past generations, and on behalf of those of the present and future, we envision an ecosystem where the resources and natural processes are in harmony under a stewardship worthy of the Grand Canyon.

We advise the Secretary of the Interior on how best to protect, mitigate adverse impacts to, and improve the integrity of the Colorado River ecosystem affected by Glen Canyon Dam, including natural biological diversity (emphasizing native biodiversity), traditional cultural properties, spiritual values, and cultural, physical, and recreational resources through the operation of Glen Canyon Dam and other means.

We do so in keeping with the federal trust responsibilities to Indian tribes, in compliance with applicable federal, state, and tribal laws, including the water delivery obligations of the Law of the River, and with due consideration to the economic value of power resources.

This will be accomplished through our long-term partnership utilizing the best available scientific and other information through an adaptive ecosystem management process.

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### **Principles**

The Glen Canyon Dam Adaptive Management Work Group embraces the following Principles. They guided development of the Goals and Objectives for the Glen Canyon Dam Adaptive Management Program (GCDAMP). These Principles are:

The Goals represent a set of desired outcomes that together will accomplish our Vision and achieve the purpose of the Grand Canyon Protection Act. Some of the Objectives and actions that fall under these Goals may not be the responsibility of the GCDAMP, and may be funded by other sources, but are included here for completeness.

The construction of Glen Canyon Dam and the introduction of non-native species have irreversibly changed the Colorado River ecosystem.

Much remains unknown about the Colorado River ecosystem below Glen Canyon Dam and how to achieve GCDAMP ecosystem Goals.

The Colorado River ecosystem is a managed ecosystem. An ecosystem management approach, in lieu of an issues, species, or resources approach, will guide our efforts. Management efforts will prevent any further human-induced extirpation or extinction of native species.

An adaptive management approach will be used to achieve GCDAMP ecosystem Goals, through experimentation and monitoring, to meet the intent of the Grand Canyon Protection Act, the Environmental Impact Statement, and the Record of Decision.

Management actions, including changes in dam operations, will be tried that attempt to return ecosystem patterns and processes to their range of natural variability. When this is not appropriate, or beyond the range of operational flexibility of the dam, experiments will be conducted to test other approaches.

Because management actions to achieve a Goal may benefit one resource or value and adversely affect another, those action alternatives that benefit all resources and values will be pursued first. When this is not possible, actions that have a neutral impact, or as a last resort, actions that minimize negative impacts on other resources will be pursued, consistent with the final Glen Canyon Dam EIS and the Record of Decision.

Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.

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Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						
	Maintain	Algae and	Biomass	Mainstem	$17.5 \text{ g/m}^2 \text{ (Cobble)}^{(27)}$	150 g/m <sup>2(27)</sup>	Also see McKinney et

_	Maintain	Algae and	Biomass	Mainstem	$17.5 \text{ g/m}^2 \text{ (Cobble)}^{(27)}$	150 g/m <sup>2(27)</sup>	Also see McKinney et
	or attain	periphyton	·	from Glen	$2.7 \text{ g/m}^2 \text{ (Pool)}^{(27)}$		al. 1999 <sup>(22)</sup>
			Composition	Canyon Dam	49.60% Cladophora	Obtain from literature	Metric is % of algal
				to Paria River	33.10% Chlorophyta		species that support
					9.10% Fontinalis		upright diatoms
					3.35% Chromophyta		1
					2.40% Rhodophyta		
					2.50% Cyanobacteria		
					(77)		
			Production		Information Need	Information Need	Metric is g/m²/time of
							Cladophora
7	Maintain	Benthic	Biomass	Mainstem	5.0 g/m <sup>2</sup> (Cobble) <sup>(27)</sup>	5000 g/m <sup>2(27)</sup>	Also see McKinney et
	or attain	invertebrates		from Glen	$1.0 \text{ g/m}^2 \text{ (Pool)}^{(27)}$		al. 1999 <sup>(22)</sup>
			Composition	Canyon Dam	0.4% Worms	Information Need	Metric is relative % of
_				to Paria River	3.6% Gammarus		species.
					5.5% Oligochaetes		
	,				0.1% Simulium		
					28.8% Midges		
					3.8% Miscellaneous		
				_	57.7% Gastropoda		
					(Cobble) <sup>(27)</sup>		
					1.0% Worms		
					0.9% Gammarus		
					35.7% Oligochaete		
					22.3% Midges		
					(Pool) <sup>(27)</sup>		
			Production		Information Need	Information Need	Metric is g/m²/time

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Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

Mainstem from Glen Canyon Dam to Paria River Mainstem below the on Paria River
Maintain or attain       Aquatic macrophytes       Biomass       Mainstem from Glen         Maintain or attain or attain or attain       Algae and periphyton       Biomass       Mainstem below the below the below the beneation
Maintain Aquatic Biomass or attain macrophytes Composition Maintain Algae and Biomass or attain periphyton Composition
Maintain Aquatic or attain macrophytes  Maintain Algae and or attain periphyton
Maintain or attain or attain
د 4

Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

Comments

To the target level

From the current level

At some place

On some attribute

On some element

Perform

#QI

some action

Information Need				<b></b>										
וָמ	וומנסגו	osO %		7.4	34.5	84.1	82.0	23.9		0.0	0.0	0.0	0.0	0.3
	MB	VW %	$e^{(27)}$	43.3	43.1	7.2	12.4	12.4	(12)	40.0	71.4	20.0	84.8	29.5
מ.	ıoydop	א כושי	Cobble <sup>(27)</sup>	49.3	22.4	8.7	9.9	63.7 12.4	Pool	60.0 40.0	28.6	80.0	15.2	712 28 5
		əliM		2	19	89	127	205		2	19	89	127	205
Mainstem	below the Paria River													
Distribution	· +													
Algae and	periphyton													
Maintain	or attain													
										(1	pən	nit	uoc	)

Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of <u>desired species at higher trophic levels</u>

Comments		Metric is relative % of	species.															Metric is g/m²/time							
To the target level	Obtain from literature	Obtain from literature																Information Need	Information Need						
From the current level	0.960 g/m <sup>2</sup> (Cobble) <sup>(27)</sup> 0.054 g/m <sup>2</sup> (Pool) <sup>(27)</sup>	0.4% Worm	7.1% Gammarus	8.2% Oligochaete	4.3% Simulium	55.4% Chironomid	3.6% Miscellaneous	21.0% Gastropod	$(Cobble)^{(27)}$	0.4% Worm	1.1% Gammarus	30.1% Oligochaete	14.3% Simulium	48.9% Chironomid	1.2% Miscellaneous	4.0% Gastropod	$(Pool)^{(27)}$	Information Need	20 Worms	500 Gammarus	120 Oligochaetes	10 Simulium	2150 Midges	20 Miscellaneous	1580 Gastropod
At some place	Mainstem below the	Paria River																							
On some attribute	Biomass	Composition																Production	Distribution						
On some element	Benthic invertebrates										••••														
Perform some action	Maintain or attain																								
#QI	5		,																						

(Cobble at Mile 2)<sup>(27)</sup>

Goal I. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels

Comments			
To the target level			
From the current level			
At some	place		
On some	attribute		
On some	element		
Perform	some	action	
#CII			

						_	_		_	
							CPOM is coarse	particulate organic	matter. FPOM is fine	particulate OM.
Information Need	Information Need	Information Need	Information Need	Obtain from literature			Obtain from literature			
Obtain from literature	Obtain from literature	Obtain from literature	Obtain from literature	$0.024 \text{ g/m}^3/\text{s}$ (Plants)	$0.056 \text{ g/m}^3/\text{s}$ (Detritus)	$0.001 \text{ g/m}^3/\text{s}$ (Inverts)	29.2% (Plants)	69.3% (Detritus)	1.1% (CPOM inverts)	0.4% (FPOM inverts)
Mainstem	below the	Paria River		Mainstem	below GCD					
Biomass		Production	Distribution	Abundance			Composition			
Aquatic	macrophytes			Foodbase	drift					
Maintain	or attain			Maintain	or attain					
9				7						
			-							

Goal 2. Maintain or attain viable populations of existing native fish and remove jeopardy from humpback chub and razorback sucker.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						

∞	Maintain	Humpback	Abundance	LCR and	8096 individuals <sup>(3, 36)</sup>	Information Need	Target to be based on
	or attain	chub (150		mainstem			91-96 population
		mm and	<del>-</del>	within 3			estimate, PVA, & No
		larger)		miles of LCR			
				Mainstem	225 individuals <sup>(3; 36)</sup>	Information Need	Target to be based on
				except within			91-96 population
				3 miles of the			estimate, PVA, & N.
				LCR	-		
6	Maintain	Humpback	Abundance	LCR and	Obtain from literature	Information Need	Metric is "catch per unit
	or attain	chub (51 mm		mainstem			effort" (CPUE). Sec
		to 150 mm)		within 3			Gorman and
				miles of LCR			Bramblett. (9) Sec
							synthesis by Coggins.
				Mainstem	0-74 captures/trip <sup>(9)</sup>	Information Need	
				except within			
				3 miles of the	,		
				LCR			
91	Establish	Humpback	Populations	CRE	One self-sustaining	One additional self-	
		chub		downstream	population in the LCR	sustaining population	
		,		ofGCD			

woal 2. Maintain or attain viable populations of existing native fish and remove jeopardy from humpback chub and razorback sucker.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place		)	
=	Attain	Humpback	Condition	LCR and	Information Need	Information Need	
		chub		mainstem			
			=	within 3			
				miles of LCR			
				Mainstem	Information Need	Information Need	
				except within			
	-			3 miles of the			
				LCR			
			Health	LCR and	Information Need	Information Need	
				mainstem			
				within 3			
				miles of LCR			
				Mainstem	Information Need	Information Need	
				except within			
				3 miles of the			
				LCR			
12	Maintain	Humpback	Spawning	LCR and	Information Need	Information Need	See Gorman and
	or attain	chub		mainstem			Bramblett. (9)
				within 3			
				miles of LCR			
				Mainstem	Information Need	Information Need	See Gorman and
				except within			Bramblett.(%)
				3 miles of the			
				LCR			

Goal 2. Maintain or attain viable populations of existing native fish and remove jeopardy from humpback chub and razorback sucker.

some element attribute place	Perform	On some	On some	At some	From the current level	To the target level	Comments
acitoe .	some	element	attribute	place			
action	action	· · · · · · · · · · · · · · · · · · ·			-		

13	Reduce	Non-native	Predation on	CRE below	Information Need	Information Need	Metric is rate of
			native fish	CCD			predation. See Gorman
			-				and Bramblett. (9)
			Competition	CRE below	Information Need	Information Need	
			with native	GCD			
			fish				
14	Attain	Razorback	Populations	CRE below	0 individuals <sup>(9)</sup>	Information Need	Target is capability of
		sucker		GCD			the habitat to support
							the species
15	Maintain	Flannelmouth	Abundance	CRE below	113 captures (5.3%) <sup>(9)</sup>	Information Need	Appropriate metric to be
		sucker		CCD			determined
		Bluehead			41 captures (1.9%) <sup>(9)</sup>	Information Need	Appropriate metric to be
		sucker					determined
		Speckled			391 captures (18.2%) <sup>(9)</sup>	Information Need	Appropriate metric to be
		dace					determined

Goal 3. Restore populations of extirpated species, as feasible.

Comments		
To the target level		
From the current level		
At some	place	
On some	attribute	
On some	element	
Perform	some	action
#01		

:	_	_				
	Information Need		Information Need	Information Need		Information Need
	0 individuals <sup>(9)</sup>		0 individuals <sup>(9)</sup>	0 individuals <sup>(9)</sup>		0 individuals <sup>(10)</sup>
	CRE	downstream	of GCD			
	Abundance	٠.	÷			
	Colorado	pikeminnow	Bonytail	Roundtail	Chub	River otter
	Restore					
	16	-				· · · · · · · · · · · · · · · · · · ·

Goal 4. Maintain a wild reproducing population of rainbow trout above <del>Lees Ferrythe Paria River,</del> to the extent practicable and consistent with the maintenance of viable populations of native fish.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						

17	Maintain	Rainbow	Abundance	Mainstem	+	100,000 Age II+	
	or attain	trout	=	from Glen		individuals	
			Growth rate	Canyon Dam	15" by Age III <sup>(23)</sup>	18" by Age III	
			Condition	to Paria River $W_r = 0.82^{(23)}$	$W_r = 0.82^{(23)}$	$W_{r} = 0.90$	
			Health		Information Need	Information Need	Metric is level of
							disease and parasite
							infections
			Spawning		Information Need	Information Need	

Goal 5. Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						

81	Attain	Water	Temperature range	Mainstem	6.93-18.56 °C <sup>(17)</sup>	Use decision process	Target may include several stations in the mainstem.
			Seasonal variability of temperature		Information Need	Use decision process	
61	Maintain	Water	Quality	Mainstem	Information Need (for	Obtain from literature	Parameters may include
					the specific water quality parameters to	and use decision process	DO, nitrogen,
					use).		phosphorus, microbes,
							and others. Data
				_			available from
•				i	·	ï	NASQWAN <sup>(35)</sup>
20	Maintain	Flow	Power plant	Mainstem	ROD operating criteria	Current ROD operating	See MO 50 for
		dynamics	operations			criteria	experimental flows
			BHBF flows		Maximum 45,000 cfs		
	,				(March to April)		
			Habitat		ROD operating criteria		
			maintenance				
			flows				:

Goal 6. Increase fine sediment storage Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Comments		
To the target level	-	
From the current level		
At some	place	
On some	attribute	
On some	element	
Perform	some	action
#QI		

Metric is area (m <sup>2</sup> ) and	volume $(m^3)$ as a rolling	average. Target level	should consider	spawning habitat for	trout in Glen Canyon.	Also see Kondolf. (16)	Target level should	consider spawning	habitat for trout in Glen	Canyon.	Metric is # sandbars by	reach. Target level	should consider	spawning habitat for	trout in Glen Canyon.	Metric is area (m²) and	volume (m <sup>3</sup> ) as a rolling	average		Metric is # sandbars by	reach
Information Need						Information Need					Information Need					Information Need			Information Need	Information Need	
329,000 m <sup>3</sup> (35 sites) <sup>(12</sup> ;	31)					0.3-0.4 mm <sup>(12; 31)</sup>					Information Need					289,120 m <sup>3</sup> (35 sites) <sup>(12</sup> :	31)		0.15-0.18 mm <sup>(12, 31)</sup>	Information Need	
Main channel		plant capacity														Eddies up to	power plant	capacity			
Abundance	=					Grain-size		_			Distribution					Abundance			Grain-size	Distribution	
Sediment					•											Sediment	-				
Maintain	or attain															Maintain	or attain				
21				_									····			22					

Goat 6. Increase fine sediment storage Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

_			=7	$\overline{}$	_				-	_
Comments				Metric is area (m <sup>2</sup> ) and	<b>volume (m³) as</b> a rolling	average			Metric is # sandbars by	reach
To the target level	1			Information Need	,			Information Need	Information Need	
From the current level				0.37m (Glen Canyon)	0.60m (Marble Canyon)	0.80m (Grand Canyon)	(12)	0.15-0.18mm <sup>(31)</sup>	Information Need	-
At some	place			Shorelines	between	power plant	capacity and	maximum	BHBF	
On some	attribute			Abundance	=			Grain-size	Distribution	
On some	element			Sediment						
Perform	some	action		Maintain	or attain					
#OI				23						

Goal 7. Maintain or attain viable populations of Kanab ambersnail.

pril 1999) lay 1999) lay 1999) ept/Oct 1999) als below s stage) <sup>(24)</sup> luals luals luals (Blves) luals (Deer (1) lower) watercress) w 70,000 cfs	#DI	ID# Perform	On some	On some	At some	From the current level	To the target level	Comments
Attain and Kanab Population Vasey's 7100 (April 1999)  Maintain ambersnail 20,000 (July 1999)  Maintain Kanab Habitat Vasey's (Reyhole)  Maintain Kanab Habitat Vasey's (Ronkeyflower)  Maintain Ranab Habitat Paradise (Monkeyflower)  Sactoory(24)  Attain and Population Vasey's (Reyhole)  Paradise (Monkeyflower)  Sactoory(24)  Attain and Ranab Habitat Vasey's 82-99m²  Sactoory(24)  Attain and Ranab Habitat Paradise (Monkeyflower)  Sactoory(24)		some	element	attribute	place		•	
Attain and Kanab Population Vasey's 7100 (April 1999)  maintain ambersnail (1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1		action						
Attain and Kanab         Population         Vasey's and between the paradise and the								
maintain         ambersnail         Paradise         6400 (May 1999)           20,000 (July 1999)         20,000 (July 1999)           35,000 (Sept/Oct 1999)         35,000 (Sept/Oct 1999)           (Individuals below         70,000 cfs stage)( <sup>24</sup> )           AZ (except         3 individuals           Vasey's         (Keyhole)           Paradise         21 individuals (Deer Creek) <sup>(1)</sup> Maintain         Kanab         Habitat         Vasey's         82-99m²           Maintain         Kanab         Habitat         Vasey's         82-99m²           Astacalise         (monkeyflower)         36.6 m² (watercress)           (area below 70,000 cfs         642,000	24	Attain and		Population	Vasey's	7100 (April 1999)	Information Need	The metric is the
20,000 (July 1999)   35,000 (Sept/Oct 1999)   35,000 (Sept/Oct 1999)   (Individuals below 70,000 cfs stage) <sup>(24)</sup>   AZ (except 3 individuals Vasey's (Keyhole)   Paradise   21 individuals (Blves)   0 individuals (Beer Creek) <sup>(1)</sup>   Asnab Habitat Vasey's 82-99m²   (monkeyflower)   36.6 m² (watercress)   (area below 70,000 cfs etages) <sup>(24)</sup>   (area below 70,000 cfs et		maintain	ambersnail	-	Paradise	6400 (May 1999)		population parameter(s)
35,000 (Sept/Oct 1999)   (Individuals below 70,000 cfs stage) <sup>(24)</sup>   AZ (except 3 individuals Subset 10,000 cfs stage) <sup>(24)</sup>   AZ (except 3 individuals Subset 10,000 cfs stage) <sup>(24)</sup>   AZ (except 3 individuals Subset 10,000 cfs stage) <sup>(24)</sup>   AZ (except 3 individuals Subset 10,000 cfs stage) <sup>(24)</sup>   Az (except 3 individuals (Elves)				=		20,000 (July 1999)		that indicate viability.
(Individuals below 70,000 cfs stage) <sup>(24)</sup> AZ (except 3 individuals Vasey's (Keyhole) Paradise) 21 individuals (Blves) 0 individuals (Decr Creek) <sup>(1)</sup> Maintain Kanab Habitat Vasey's 82-99m² ambersnail Paradise (monkeyflower) 36.6 m² (watercress) (area below 70,000 cfs etages) <sup>(24)</sup>						35,000 (Sept/Oct 1999)		Target is a viable
Maintain Kanab Habitat Vasey's (monkeyflower)  Maintain Kanab Habitat Vasey's (monkeyflower)  AZ (except 3 individuals Vasey's (Keyhole)  Paradise) 21 individuals (Elves)  O individuals (Deer Creek) <sup>(1)</sup> (monkeyflower)  36.6 m² (watercress)  (area below 70,000 cfs		-				(Individuals below		population.
Maintain Kanab Habitat Vasey's (Reyhole)  Maintain Kanab Habitat Vasey's (Reyhole)  Maintain Kanab Habitat Vasey's 82-99m²  (monkeyflower)  36.6 m² (watercress)  (area below 70,000 cfs						70,000 cfs stage) <sup>(24)</sup>		•
Maintain       Kanab       Habitat       Vasey's vasey's (monkeyflower)       (Keyhole)         Paradise       21 individuals (Elves)         0 individuals (Deer Creek) <sup>(1)</sup> Ashab       Habitat       Vasey's (monkeyflower)         Baradise       (monkeyflower)         36.6 m² (watercress)         (area below 70,000 cfs					AZ (except	3 individuals	Information Need	The metric is the
Maintain Kanab Habitat Vasey's 82-99m² ambersnail Abradise Paradise 21 individuals (Elves)  O individuals (Elves)  Creek) <sup>(1)</sup> Ranab Habitat Vasey's 82-99m² (monkeyflower) 36.6 m² (watercress) (area below 70,000 cfs					Vasey's	(Keyhole)		population parameter(s)
Maintain Kanab Habitat Vasey's 82-99m² ambersnail Paradise (monkeyflower) 36.6 m² (watercress) (area below 70,000 cfs					Paradise)	21 individuals (Elves)		that indicate viability.
Maintain Kanab Habitat Vasey's 82-99m² ambersnail Paradise (monkeyflower) 36.6 m² (watercress) (area below 70,000 cfs						0 individuals (Deer		Target is a viable
Maintain Kanab Habitat Vasey's 82-99m <sup>2</sup> ambersnail Paradise (monkeyflower)  36.6 m <sup>2</sup> (watercress)  (area below 70,000 cfs						Creek) <sup>(1)</sup>		population.
Paradise	25	Maintain	Kanab	Habitat	Vasey's	82-99m <sup>2</sup>	Information Need	Target is level needed to
$36.6 \text{ m}^2 \text{ (watercress)}$ (area below 70,000 cfs			ambersnail		Paradise	(monkeyflower)		sustain a viable
(area below 70,000 cfs						36.6 m <sup>2</sup> (watercress)		population.
stace)(24)						(area below 70,000 cfs		
orașe)						stage) <sup>(24)</sup>		

Gom 8. Protect the presence of southwestern willow flycatcher and its critical habitat in a manner consistent with riparian ecosystem goals.

Comments	The target is the number of breeding pairs that the habitat is capable of supporting.	The target is the distribution of breeding pairs that the habitat is capable of supporting.	See GCMRC <sup>(7)</sup>		
To the target level	Information Need	Information Need	Information Need	Information Need	Information Need
From the current level	12 breeding pairs <sup>(26)</sup>	Information Need	Information Need	Information Need	50% of nests parasitized <sup>(2)</sup>
At some place	CRE below GCD	CRE below GCD	CRE below GCD	CRE below GCD	CRE
On some attribute	Abundance	Distribution	Fledging success	Critical habitat	Brood parasitism
On some element	Southwest willow flycatcher			Southwest willow flycatcher	Brown- headed cowbird
ID# Perform some action	Maintain or increase			Maintain	Reduce
#OI	26			27	28

Goal 9. Protect or improve the biotic riparian and spring communities.

Comments	11	Stevens et al (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)	See Kearsley <sup>(15)</sup> and	Stevens et al. (29)
To the target level	Information Mad		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need		Information Need	
From the current level	1215 patches (4 6 ha) <sup>(7)</sup>	(	Information Need		Information Need		Information Need	-	Information Need		Information Need		Information Need		Information Need	,	Information Need		Information Need		Information Need		Information Need	
At some place	CRE below	GCD		· •			CKE below	3					CRE below	- dcp					CRE below	- C.D.				
On some attribute	Abundance	1	Composition	District	Distribution		Abundance		Composition		Distribution	,	Abundance		Composition		Distribution		Abundance		Composition		Distribution	
On some element	Marsh			_		M	New nign	water 20115					Old high	water zone				-	Sand beach	•				
Perform some action	Maintain					Meintein	Mailliaili					7.7	Maintain					. , . , . , . ,	Maintain					
#QI	50					30	2					,	21					2,2	76					

Goal 9. Protect or improve the ototic riparian and spring communities.

Comments		i
To the target level		
From the current level		
At some	place	
On some	attribute	
On some	element	
Perform	some	action
ID# P		

-					
	See MO 42 – MO 33 may be redundant				
	Information Need	Information Need	Information Need		Information Need
	157 species (Plants) <sup>(21;</sup> <sup>30)</sup>	Information Need	95+ species (Plants) <sup>(28)</sup>	3 species (Birds) <sup>(28)</sup>	Information Need
	CRE below GCD		CRE below	GCD	
	Abundance Composition	Distribution	Abundance		Distribution
	Culturally important	species	Invasive non- Abundance	native species	•
	Preserve: Culturally stabilize or important	improve	34 Reduce		
	33		34		

Goal 10. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

Comments		
To the target level		
From the current level		
At some	place	
On some	attribute	
On some	element	
Perform	some	action
#DI		

Target level should be	within the capacity of	the CRE to absorb	visitor impacts. Target	level should consider	GLCA and GRCA	Management Plans. See	Myers et al. (25)	Target level should be	within the capacity of	the CRE to absorb	visitor impacts. Target	level should consider	GLCA and GRCA	Management Plans. Sec	Myers et al. (25)	Target level should be	within the capacity of	the CRE to absorb	visitor impacts. Target	level should consider	GLCA and GRCA	Management Plans. See	Myers et al. (23)	Metric includes	parameters for	vegetation, sanitation,	and shade
Information Need								GLCA Management	Plan levels							Information Need								Information Need			
Information Need								Information Need								Information Need								Information Need	,		
Mainstem								Glen Canyon	,							Mainstem											
Physical	access and	safety						Quality and	quantity							Size								Quality			
Visitor								Recreational	spectrum							Camping	beaches		•			·					
Maintain								Maintain	or improve							Maintain	or increase										
35								36								37											

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Goal 10. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments	
	some	element	attribute	place				
	action							

į						
			Target level to be	developed from NPS	on-river accident rates.	See Myers et al. (25)
	Information Need	Information Need	Information Need			
	262 campsites <sup>(14)</sup>	37% of campsites in critical reaches <sup>(14)</sup>	Information Need			ı
			Mainstem			
	Number	Distribution	Navigability			
			Rapids		-	
			Maintain	or improve		
			38			

Goal 10. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

	а .	=	_	_	_						_
Comments		Metric to include	parameters for primitive	character, uncontined	experience,	undeveloped natural and	wild character,	opportunities for	solitude, sounds of	nature and scenic	beauty.
To the target level		Information Need							-		
From the current level		Information Need									
At some place		Grand	Canyon								
On some attribute		Wilderness	•								
On some element		Experience									
Perform some action		39 Maintain	or enhance								
#Q1		39									

Goal 11. Maintain or increase power and energy generation within the framework of GCDAMP ecosystem goals.

i					ſ	
	Commente					
	To the target level				Information Need	
	From the current level				ROD and current	operating practices (33)
	At some	place			CCD	
0.00	On some	attribute			Generation	flexibility
Oncomo		element			Power	
ID# Perform		some	action	-	Maintain	or increase
11)#				7	04	

Goal 12. <u>Preserve, protect, manage, and treat</u> <u>C</u>cultural resources <del>within the river corridor shall be preserved, protected, managed and treated for the inspiration and benefit of past, present and future generations.</del>

Preserve   Register   National   APE   Information Need   To the target level   Commernts		ត		_				_												_		_	_					_		
# Perform On some on some ditribute place action  Preserve Register- National Register properties integrity resources (obtained through integrity maintain and AMP Government consultation and maintain resources  Protect Traditional Physical CRE Information Need (obtained through ethnographic studies, polls, interviews, surveys, and literature) and consultation and and access and information Need (obtained through ethnographic studies, polls, interviews, surveys, and literature) and consultation and and access and information Need Information Need (Information Need Information Need (Information Need Information N	Comments		Preserve via protection,	management, and/or	treatment for the	purpose of federal	agency compliance with	the NHPA and	AMP/AMWG	compliance with GCPA.	Purpose is to preserve	(stabilize or improve	based on current	cultural values) other	traditionally important	resources that are not	sufficiently addressed	under other Mos.	Attain and maintain a	government to	government consultative	relationship regarding	all AMP activities.		AMP won't knowingly	restrict or block	physical access by	Native American	religious practitioners.	SEE AIRFA & EO
# Perform On some On some At some some element attribute place clement properties integrity properties integrity integrity resources important integrity resource CRE maintain resource to maintain resource to maintain and AMP Government consultation management actions  Protect Traditional Physical CRE and cultural access maintain resources	To the target level		100% of extant historic	properties							Stable or improving for	each identified resource							100% of AMP actions						Information Need					
# Perform On some clement attribute action  Preserve Register- National eligible properties integrity resource important integrity resource important resource to maintain resource to management actions  Protect Traditional Physical and cultural access maintain resources	From the current level		Information Need	(> 265 historic	properties)				-		Information Need	(obtained through	ethnographic studies,	polls, interviews,	surveys, and literature)				Existing Level: TWG,	AMWG, and PA	meetings. \$75,000	(appropriated) &	\$400,000 (power	revenues)	Information Need					
# Perform On some on some some element attribute action  Preserve Register- National Register properties integrity resources important integrity resources  Attain and AMP Governme and management actions  Protect Traditional Physical and cultural access	At some place		APE		_						CRE								CRE			-			CRE					
# Perform some action Preserve Preserve maintain Protect and maintain	On some attribute		National	Register	integrity						Resource	integrity							Government	to	Government				Physical	access				
#	On some element		Register-	eligible	properties						Traditionally	important	resources						AMP	resource	monitoring	and	management	actions	Traditional	cultural	resources			
1D# 44 44	Perform some action		Preserve								Preserve	_							Attain and	maintain					Protect	and	maintain			
	#QI		41	•							42								43						4					

Gous 12. <u>Preserve, protect, manage, and treat</u> C<u>cultural resources within the river corridor shall be preserved, protected, managed and tre</u>ated

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						

			-				13007; meaningful	
			Ŧ				consultation issue.	
45	45 Integrate	Cultural & Increased	Increased	CRE	Not readily available	Readily accessible by	See cultural resources	
	ઝ	environmenta interdisciplin	interdisciplin		and not synthesized or	georeferencing using	PEP report.	
	synthesize   1 data	l data	ary		integrated	GIS, databases, etc.		
			understanding					
			of the		-			
			ecosystem					
			and its history					

Goal 13. Maintain a high-quality monitoring, research, and adaptive management program.

Maintain and Monitoring maintain and Maintain and Maintain composed of maintain and AMP stain and AMP maintain all stakeholders		- 3								-	T			-					
Perform On some   At some   From the current level	Comments	The current level is how	much socioeconomic	data we have on the attributes. The target	level is how much	socioeconomic data is	ilected for adequate	decision-making.											
Maintain and Monitoring Maintain and Attain and AMP  Perform On some attribute place attribute place Air quality N/A Non-use N/A Non-use N/A Non-use N/A Non-use N/A Spiritual AMP Tribal & N/A Spiritual CRE Tribal & N/A Spiritual AMP That recreational recreational resources Attain and AMP That uncertainty stakeholders and uses experimentati	To the target level	Information Need	Information Need	Information Need	Information Need	Information Need		Information Need			Updated GCMRC	Strategic Plan	<b>)</b>		Information Need				
Maintain and Monitoring Natural, and maintain composed of maintain some composed of acknowledges and uses actional and and research cultural, and program recreational resources all and uncertainty and stakeholders and uses experimentality and stakeholders experimentality composed of experimentality and stakeholders experimentality experimentality experimentality experimentality experimentality experimentality experimentality	From the current level	Information Need	Information Need	Information Need	Information Need	Information Need		Information Need			GCMRC Strategic Plan	)			Information Need				
Maintain and Monitoring maintain and Monitoring all stakeholders	At some place	N/A	N/A	N/A	N/A	N/A		N/A			CRE				N/A				
Maintain or attain and maintain maintain	On some attribute	Hydropower	Air quality	Wildemess	Recreation	Non-use	values	Tribal &	spiritual	values	Natural,	cultural, and	recreational	resources	That	acknowledges	uncertainty	and uses	experimentati
#	On some element	Socio-	economic data								Monitoring	and research	program		AMP	composed of	all	stakeholders	
#0 1D#		Maintain	or attain								Attain and	maintain			Attain and	maintain			
	ID#	46									47				48				

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Information Need

See meeting records

on, monitoring &

research Participation

Information Need

0

CRE

Tribal AMP
Participation
(need to
define tribal
participation)

Management, research, and monitoring

Attain and maintain

49

activities

Goal 13. Maintain a high-quality monitoring, research, and adaptive management program.

Comments	Target level is the experiments needed to gain critical understanding of ecosystem function under different dam operations.	Target level is the experiments needed to gain critical understanding of ecosystem function under different management alternatives outside of dam operations.	Metric should include GCMRC and BOR web pages; GCD programs and tours; AMWG Outreach Committee; publications; various AMWG member activities.	
To the target level	Information Need	Information Need	Information Need	Information Need \$1,485,000 (FY2002) Information Need Information Need
From the current level	Information Need	Information Need	Information Need	\$0 \$75,000 (FY2000) Obtain from literature \$6.22M (for GCMRC) \$1.443M (for BOR)
At some place	Mainstem	CRE	N/A	N/A N/A N/A
On some attribute	Flow dynamics	Other management actions	Public support	Foundation and Corporate Appropriated State Agency Power revenues
On some element	Experimental flows	Management experiments	AMP :	Funding
Perform some action	Conduct	Conduct	Build	Maintain or attain
#QI	50	51	52	53

Goal 13. Maintain a high-quality monitoring, research, and adaptive management program.

#QI	D# Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action						
54	Maintain	Participation Externally-	Externally-	CRE	Information Need	Information Need	Current and target levels
	or attain		funded				should include small
			investigators				and cost-shared projects
							in NPS, AGFD, etc.

Goal 14. Build a broad, effective outreach program.. NOTE: This goal is now part of Goal 13.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place			
	action			•			

Goal 15. Broaden the funding base to achieve GCDAMP Goals and Objectives. NOTE: This goal is now part of Goal 13.

#QI	Perform	On some	On some	At some	From the current level	To the target level	Comments
	some	element	attribute	place		io an pagrin ou	Comments
	action						

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#### ADAPTIVE MANAGEMENT

Adaptive management is an iterative process, designed to experimentally compare selected management actions by evaluating alternative hypotheses about the ecosystem being managed. It consists of three parts: management actions, monitoring, and adaptation. Management actions are treated as experiments subject to modification. Monitoring is conducted to detect the effects of the management actions. Finally, management actions are refined based on the enhanced understanding about how the ecosystem responds.

#### BIODIVERSITY

Biodiversity is "the variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels [including] ... the variety of ecosystems..."(38)

#### **BIOTIC COMMUNITY**

A biotic community is a "group of organisms ... that co-occur in the same habitat or area and interact through trophic and spatial relationships..." (20)

#### COLORADO RIVER ECOSYSTEM

The Colorado River ecosystem is the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park. It includes the downstream inundation level to which dam operations impact physical, biological, recreational, cultural, and other resources. The scope of GCDAMP activities may include limited investigations into some tributaries (e.g., the Little Colorado and Paria Rivers).

#### CONCEPTUAL MODEL

A conceptual model is an "assessment of the dynamics of the more important compartments and fluxes of material or energy in a system [i.e., patterns and processes], or of changes in a population." (20) A conceptual model is a heuristic tool to provide a framework for thinking about how an ecosystem functions and to discover gaps in our knowledge.

# **CULTURAL RESOURCES**

Cultural resources includes, but is not necessarily limited to, any prehistoric or historic district, site, building, structure, landscape, or object included in, or eligible for inclusion in the National Register, including artifacts, records, and material remains related to such a property or resource. Properties of traditional religious and cultural importance to an Indian tribe are included in this definition under Section 101(d)(6)(A) of NHPA.

## **ECOSYSTEM**

An ecosystem is "a community of organisms and their physical environment interacting as an ecological unit." An ecosystem consists of patterns and processes that are dynamic and occur within a particular range of temporal and spatial variability.

#### **ECOSYSTEM INTEGRITY**

Ecosystem integrity is "the ability to support and maintain a balanced, integrated, adaptive biological system having the full range of elements (genes, species, and assemblages) and

# Glossary

processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region." (13) Ecosystem integrity is related to ecosystem resilience (i.e., the capacity to maintain characteristic patterns and processes) following a disturbance.

## **ECOSYSTEM MANAGEMENT**

An ecosystem management approach differs from an issue-, species-, or resource-specific approach. Ecosystem management is a method for sustaining or restoring ecosystems and their functions and values. "It is goal driven, and it is based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries." (11) Ecosystem management is a process that attempts to mimic appropriate ecosystem patterns (abundance and distribution of species and habitats) and ecosystem processes (drivers of ecosystem patterns). It includes managing for viable populations of all native species.

#### **ECOSYSTEM PATTERNS**

Ecosystem pattern is the abundance of species, biotic communities, and physical habitats, as well as their spatial and temporal distribution. This is a broader concept than "composition and structure." Composition usually refers only to species presence or absence, and structure usually refers to the distribution of biotic communities.

#### **ECOSYSTEM PROCESSES**

Ecosystem processes are the abiotic (i.e., non-living) and biotic (i.e., living) functions, disturbances, or events that shape ecosystem patterns. There are physical processes (e.g., fire, hydrologic, geomorphic, and climatic regimes; air chemistry, nutrient cycling), biological processes (e.g., competition, predation, herbivory, parasitism, disease, migration, dispersal, gene flow, succession, recruitment, maturation), and anthropogenic processes (e.g., habitat conversion, novel toxins, vandalism).

# **MONITORING**

Monitoring is the "collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective." Monitoring needs to produce data of sufficient statistical power to detect a trend if in fact it is occurring. Monitoring differs from inventorying, which is the measurement of environmental attributes at a given point in time to determine what is there. It also differs from research, which is the measurement of environmental attributes to test a specific hypothesis.

#### RANGE OF NATURAL VARIABILITY

The Range of Natural Variability is the spatial and temporal variation in ecosystem patterns and ecosystem processes under which the ecosystem has evolved. The range of natural variability for ecological processes is usually defined by their frequency (e.g., number/year), intensity (e.g., cubic feet per second), duration (e.g., number of days), magnitude (e.g., acres), seasonally, and rate of change. See Landres<sup>(18)</sup> for a full discussion.

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# REASONABLE AND PRUDENT ALTERNATIVE

"Reasonable and prudent alternatives refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat." (5)

# REASONABLE AND PRUDENT MEASURE

"Reasonable and prudent measures refer to those actions the Director believes necessary or appropriate to minimize the impacts, i.e., amount or extent of incidental take." (5)

# RECOVERY

Recovery is improvement in the status of a listed species to the point at which listing is no longer appropriate, under the criteria set out in section 4(a)(1) of the Endangered Species Act (5).

#### REMOVAL OF JEOPARDY

To "jeopardize the continued existence of [a listed species] means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." (5) Removing (or avoiding) jeopardy is intended to be accomplished through the implementation of reasonable and prudent alternatives.

#### RIPARIAN ECOSYSTEM

The riparian ecosystem is the streamside zone that is influenced by riverine processes, e.g., flood regime and distance to subsurface water.

# **RIVERINE ECOSYSTEM**

The riverine ecosystem is any area typically inundated by the river.

# VIABLE POPULATION

A population is considered viable when there is a high chance of persistence over a long timeframe without demographic or genetic augmentation. Population viability is not the same as "recovery" or "removal of jeopardy" for a species. However, the concept of population viability is an important consideration in determining recovery and removal of jeopardy.

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